of the source, and will be the same as if that were viewed directly. In other words, the change of wave-length depends on the *rate of change of optical path* from the source to the receiving apparatus. If the source is stationary and the mirror moved the effect is doubled whether the mirror is plane or curved.

The fallacy in Dr. Heyl's suggestion appears to lie in his considering a moving image as in all respects equivalent to a moving source. While this may be true as a proposition in geometrical optics, there is the essential physical distinction that the phase of the vibrations issuing from an image depends not only on the vibrations of the original source, but also upon the (optical) distance from that source. Doubtless if we were to follow the image with our spectroscope we should observe a change of wave-length due to the latter cause. However, even if we could surpass the feat of hitching our wagon to a star by hitching our instruments to the much more swiftly flying image, we should again have the same effect as if the source were viewed directly.

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SPECIAL ARTICLES.

GLACIAL STAGES IN SOUTHEASTERN NEW ENGLAND AND VICINITY.[1]

FOR some years the writer has been engaged on the problem of the differentiation of the Pleistocene deposits of Long Island and southeastern New England. Some of the results have already been published,[2] and reports discussing in greater detail the subdivisions recognized, and their correlation are in preparation. The completion of the reports, however, owing to the assignment of the writer to other lines of investigation, is likely to be considerably delayed, and it has, therefore, seemed advisable to present a brief statement of the Pleistocene succession in the region in question, as it is understood by the writer, in the columns of this journal.

[1] Published by permission of the director of the United States Geological Survey.

[2] 'Probable Representatives of the Pre-Wisconsin Till in Southeastern Massachusetts,' *Jour. Geol.*, Vol. 9, 1906, pp. 311–329. 'Probable Pre-Kansan and Iowan Deposits of Long Island, New York,' *Am. Geol.*, Vol. 32, 1903, pp. 308–312. 'Geology of Fishers Island, New York,' *Bull. Geol. Soc. Am.*, Vol. 16, 1905, pp. 367–390. 'Clays of Cape Cod,' Bull. 285, U. S. Geol. Survey, 1906, pp. 432–441.

Pleistocene Subdivisions.

In the area examined, which includes Long Island, Gardiner's Island and Fisher's Island, New York; Block Island and the coast of Rhode Island, and Martha's Vineyard, Nantucket, Cape Cod and the coast of Massachusetts northward to Boston, the Pleistocene events appear to have been as follows:

1. *Deposition of the Deeply Oxidized Tills and Weathered Gravels.*—At Brockton and Stoughton, in Massachusetts, and other points in the vicinity, there are several exposures of bright yellow or red till composed of the disintegrated remains of local rocks occurring in protected spots beneath the younger tills. In most cases these old tills rest on deeply weathered rock surfaces, and are believed to represent preglacial residual soils slightly reworked by the first ice advance, which appears to be pre-Kansan in age.

On Long Island the Cretaceous is overlain unconformably by several hundred feet of yellow-stained gravel containing a few deeply weathered or disintegrated granitic pebbles and an occasional erratic crystalline boulder. It was originally correlated with a part of the Pensauken of New Jersey, but was later given the name Mannetto by Veatch. It is believed to be pre-Kansan and to represent the outwash of the same glacier which further inland deposited the till described in the preceding paragraph.

2. *Long Period of Subareal Erosion.*

3. *Deposition of Granitic Gravels.*—These gravels were noted in 1903 by Veatch in the well borings of western Long Island, and in the following year were recognized by the writer in the cliffs of Block Island, Martha's Vineyard and Cape Cod. They have a maximum thickness of 100 or more feet and consist of

quartz and granitic pebbles, the latter being especially numerous in the borings of western Long Island, where the deposit seems to approach a till in character. Elsewhere the formation is often sandy and is to be regarded as an outwash from the second, probably the Kansan, glacier. The formation is known as the Jameco.

4. *Deposition of Red and Black Clays.*—These clays, known as the Gardiner, overlie the Jameco with an abrupt line of demarcation on Long Island, Fisher's Island and Block Island, and on Martha's Vineyard, Cape Cod and the Massachusetts coast to Boston. They carry a shell fauna, characteristic of a somewhat colder climate than at present. The maximum thickness is about 100 feet. In some places the clay occurs as a single bed, while at other localities it is split up into a series of clays interbedded with sands. The color varies from red, through gray and brown, to black. It is correlated tentatively with the Yarmouth interglacial deposits of the central states.

5. *Deposition of Fine Sand.*—Following the Gardiner clay a thickness of ten to thirty feet of fine sand, often almost quartz flour, was deposited. This has been designated the Jacob sand and is regarded as a transition between the Gardiner clay and the Herod gravel. It is the equivalent in part of the Sankaty beds of Nantucket, in which locality it is abundantly fossiliferous.

6. *Deposition of Granitic Gravels.*—These gravels, known as the Herod, reach a maximum thickness of 100 feet or more, and consist of layers of quartz and granitic pebbles alternating with beds of sand. They are thought to mark the beginning of a third ice invasion, possibly the Illinoisan. They occur at nearly all points from Long Island to Boston, at which locality they have been recognized beneath the till of the drumlins.

7. *Deposition of the Principal Till of New England and Erosion by Ice.*—This till, which on Long Island and Fisher's Island and Cape Cod has been called the Montauk drift, is a hard, compact, dark gray, often partly cemented till, having a maximum thickness of perhaps 75 feet on Long Island, but reaching more than double this thickness in the drumlins about Boston, which, with few, if any, exceptions, belong to this stage. It is usually oxidized to a depth of ten to twenty feet and is regarded as probably Illinoisan in age. In places the ice by which it was deposited cut deeply into the underlying formations, and the till may rest directly upon any of the older deposits. In such instances the drift often departs widely from its normal character, partaking of the nature of the local beds from which its materials were derived. It marks an actual invasion of the ice.

8. *Deposition of Granitic Gravels.*—These gravels, together with their included beds of sand and an occasional layer of brownish clay, resemble the Jameco and Herod formations and are regarded as marking the close of the third, probably the Illinoisan, stage. They may be seen at many points on Long Island and between that island and Cape Cod.

9. *Great Erosion Interval: Possible Deposition of Clay.*—Clays have been recognized above the Montauk drift in the vicinity of Plymouth, and appear to overlie the drumlins near Boston. These underlie the latest drift and may possibly belong to the Iowan stage. It may be said, however, that in the region south of Boston but little reliable evidence has yet been obtained of the existence of drift of this stage, although it is not improbable that it may be present. Deposition, at the best, appears to have been a minor feature in the interval between the gravels last mentioned and the latest till, the interval being characterized rather by extensive erosion, such as might be expected to mark a long period like the Sangamon-Iowan-Peorian interval rather than the Peorian interval alone, in which, judging from the evidences in the central United States, relatively little erosion was accomplished.

10. *Deposition of Thin Till.*—This till is usually from two to twenty feet in thickness and is ordinarily loose and bouldery rather than clayey, and is oxidized to a depth of only two to five feet. It constitutes the surface deposit over most of southeastern Massachu-

setts, but, because of its thinness, has not heretofore been separated from the main or drumlin drift (Montauk) and has even failed of recognition where present on the extensive sandy deposits of the Plymouth and Cape Cod regions of Massachusetts. On Long Island it is better developed and is everywhere recognized above the older gravels. It is presumably to be correlated with the latest drift of the Mississippi Valley—the Wisconsin.

M. L. FULLER.

UNITED STATES GEOLOGICAL SURVEY.

FOOD HABITS OF THE SNAIL BULIMULUS DORMANI BINNEY.

THE orange and other *Citrus* species, several ornamentals, and various greenhouse and other plants are often badly disfigured by the presence of a black saprophytic fungus,[1] *Meliola Camelliæ* (Catt.) Sacc. commonly known in the orange-growing region of Florida as the 'sooty mold' of the orange. The fungus feeds on a sweet honey dew exuded by various insects, especially species of Aphidæ, Coccidæ and Aleyrodidæ. The habits of the Aleyrodidæ species are very favorable to the growth of the fungus. This is especially true of the so-called 'white fly' of the orange, *Aleyrodes citri*. The larvæ of this species, attaching themselves to the under surface of the leaves, exude honey dew which, falling to the top surface of the leaves and stems beneath supplies nourishment for a heavy growth of the fungus. The white fly and the fungus are invariably associated, and a badly infested grove or hedge may be recognized at some distance by its heavily coated dark foliage. So dense is the covering of the intertwining hyphæ that the smothering layer is believed to interfere seriously with the healthy action of the sunlight on the leaves. The fruit as well as the leaves and stems is coated, and a thorough washing of the smutty oranges becomes necessary before marketing; an added expense is thereby incurred as well as increased danger of bruising from additional handling and washing, and, unless the oranges are quickly and properly dried, of decay in shipping from the wetting. The presence of the sooty mold is thus one of the most serious results of white fly infection of orange groves, and almost the only appreciable injury from this species to privet and other ornamentals, and is an important element in the injury to various plants from numerous other sucking insects.

The habits of the snail *Bulimulus Dormani* Binney[2] are of the greatest interest in this connection. This species, the normal food of which is apparently fungi, algæ and perhaps lichens, has been found during the summer of 1905 in numerous groves in Manatee County feeding on the sooty mold. The trees on which the snails are found stand out conspicuously among the surrounding trees by their bright foliage and fruit, and clean trunks, in contrast to the sooty leaves and fruit of the surrounding trees. The work of the snails on orange trees is well seen in the Willis grove of the Manatee Lemon Company near Palmetto, Florida. The trees of this grove are seedlings and reach a height of thirty to thirty-five feet. Snails are present on perhaps seventy-five trees and have completely overrun them from top to base, cleaning the fruit, leaves and trunks. The foliage of the trees not visited by the snails is densely coated by the sooty mold. The snails have not confined themselves to the fungus alone, but have freed the trees from algæ, and apparently some of the lichens. The snails are even more widely scattered in some of the neighboring groves. The species is evidently native to the Florida Peninsula, having been recorded, according to Pilsbry, 'Manual of Conchology,' Vol. 12, 1899, from the mouth of the St. Johns River south to the Caloosahatchee River. The snails appear to have found their way naturally into the groves of the Manatee region. Mr. F. D. Waite, manager of the Manatee Lemon Company, observed their presence on one or two trees in the Willis grove as early as the summer of 1903, and they seem to have appeared in other groves at about the same

[1] Saprophytic in the sense that, although following and directly dependent upon various living insects, sustenance is derived from waste products thrown off from the bodies of these insects.

[2] Kindly identified for the writer by Dr. W. H. Dall.